OXFORD JOURNALS
OXFORD UNIVERSITY PRESS

Archives of Clinical Neuropsychology 24 (2009) 293–300

Archives of CLINICAL NEUROPSYCHOLOGY

A New Emotional Stroop-Like Task: Application to the Down Syndrome Population

Loyse Hippolyte*, Katia Iglesias, Koviljka Barisnikov

Department of Psychology, Geneva University, Geneva, Switzerland

Accepted 18 June 2009

Abstract

The present study proposed to test the applicability of a new emotional Stroop-like paradigm among 49 adults with Down syndrome (DS), matched with typically developing children on gender and receptive vocabulary. Stimuli with neutral and emotional content were presented in two identical computerized tasks. This experimental design allowed comparisons of inhibition performance according to the nature of the material. Main results showed that the DS group processed the emotional material more poorly than the control group in the inhibition condition, whereas all participants performed near or at ceiling in the control condition. Regarding the response latencies, both groups processed emotional material slower than the neutral material. The DS participants did not take more time to respond than their controls, but they presented a distinct response latency pattern during the task: while the control group kept their response times constant, the DS group showed an improvement during the task.

Keywords: Stroop-like task; Emotion; Inhibition; Facial expression; Down syndrome

Introduction

The emotional Stroop is a paradigm widely used for investigating aspects of emotion processing through an inhibition measure (Amir, Freshman, & Foa, 2002; Perez-Edgar & Fox, 2003; Williams, Mark, Watts, MacLeod, & Mathews, 1997). Adapted from the classical Stroop Interference Test (Stroop, 1935), participants are asked to name the color of neutral and emotional words. The choice of emotional words is usually related to applicability in a specific clinical population (e.g., *hairy* and *crawl* for spider phobics, Watts, McKenna, Sharrock, & Trezise, 1986). It has been observed that the color-naming of emotional words is slower when compared with neutral words in clinical groups only.

The classical Stroop test—as well as its emotional adaptation—requires reading abilities, and alternative versions have been designed. One of them is the Stroop-like paradigm, which has been originally developed for young, pre-reading children. The "Day-Night" task is one of these notable extensions (Gerstadt, Hong, & Diamond, 1994). This task assesses the ability to inhibit a predominant response, such that participants are asked to respond "day" to a nighttime picture and "night" to a daytime picture. However, similarities between the Stroop test and the Day-Night task have been questioned by some authors. For Wright, Waterman, Prescott, and Murdoch-Eaton (2003), Stroop-like versions that present more stimuli, such as the fruit Stroop (Archibald & Kerns, 1999) or the animal Stroop (Wright et al., 2003), are closer to the classical Stroop test and more accurate for measuring inhibition abilities. Yet these tasks are difficult to administer to participants under the age of 7 as they contain complex stimuli and instructions.

Despite critiques, the Day-Night task remains a tool of choice for assessing inhibition abilities in young children (e.g., Carlson & Moses, 2001; Roebers & Schneider, 2005; Wolfe & Bell, 2007), and several adaptations have been developed (Archibald & Kerns, 1999; Beveridge, Jarrold & Pettit, 2002; Simpson & Riggs, 2005). In addition, this task seems to be

* Corresponding author at: 40 Bd du Pont d'Arve, 1211 Genève 4, Switzerland. Tel.: +41-22-379-93-53; fax: +41-22-379-93-59.
E-mail address: loyse.hippolyte@unige.ch (L. Hippolyte)

doi:10.1093/arclin/acp036 Advance Access publication on 8 July 2009

well suited to children and adults with intellectual disability (ID) (Atkinson et al., 2003; Tager-Flusberg, Sullivan, & Boshart, 1997; Walley & Donaldson, 2005). Of note is that all Stroop-like tasks mentioned above have used pictorial stimuli with no emotional meaning and can, therefore, be considered as counterparts of the classical Stroop. To the best of our knowledge, no emotional equivalent has yet been developed.

There are, on the other hand, many pictorial emotional Stroop versions that present emotional pictures instead of words (e.g., Constantine, McNally, & Hornig, 2001; Kindt & Brosschot, 1997; Mazurski, Bond, Siddle, & Lovibond, 1996). These pictorial tasks present an interesting non-lexical alternative for measuring inhibition abilities with emotional material. This paradigm would likely be appropriate for studying populations known for their atypical manner of processing emotional information, such as people with Down syndrome (DS; Hippolyte, Barisnikov, & Van der Linden, 2008), Williams syndrome (Gagliardi et al., 2003), or fragile X (Turk & Cornish, 1998). Persons with DS are characterized as being cheerful, and as actively seeking social contact (Dykens, Hodapp, & Evans, 1994). It has been hypothesized that DS individuals might exhibit strength when processing emotions (Kasari, Freeman, & Hughes, 2001). However, most studies in DS children have shown impairments, with specific difficulties in recognition of negative expressions such as anger and fear (Kasari et al., 2001; Williams, Wishart, Pitcairn, & Willis, 2005). Hippolyte and colleagues found that DS adults presented a positive bias when judging facial expressions and intensity of emotional expressions. Despite their ability to recognize positive and negative emotions, such as joy and sadness, they had a tendency to assess expressions as being more positive than they actually were. Furthermore, correlational analyses showed that this bias was strongly and negatively related to the Day-Night task.

The main objective of the present study is to propose an emotional Stroop-like paradigm adapted to assess people with mild and moderate ID. Relying on the assumption that emotional material is processed differently, depending on the value attributed to it, we wanted to examine inhibition abilities of DS individuals presented with emotional versus neutral material. The existing pictorial emotional Stroop tasks are too difficult for people with ID. The complex instructions and the large number of stimuli presented require important cognitive, attentional, and working memory resources. Therefore, we constructed two equivalent Stroop-like tasks, varying only the nature of their stimuli (emotional and neutral), and each containing two conditions: a control condition (name what is shown on the screen) and an inhibition condition (name the opposite of what is shown on the screen). Regarding the neutral material, we used the “Sun–Moon” task (Archibald & Kerns, 1999), an adapted version of the Day-Night task designed to obtain a lower ceiling effect. Concerning emotional material, we created the “Happy–Sad” task, the stimuli which consisted of a child displaying a happy versus a sad facial expression. Results for the DS adults were compared with those of typically developing children matched on receptive vocabulary. This matching measure seemed relevant, because the administration of the experimental tasks requires a minimum level of verbal knowledge (i.e., instruction comprehension) and verbal responses. This comparative approach allowed us to identify whether the DS adults’ performance in the Stroop-like tasks was impaired or not in terms of a quantitative score difference (e.g., presence of developmental delay). Additionally, potential atypical processing could also be revealed by qualitative differences between the groups’ patterns of performance.

The following hypotheses were proposed; With regard to the control condition, we did not expect an effect of material type on success rates for either group. As reported in the literature, faces and emotions are processed as prominent stimuli, and could be more difficult to inhibit than neutral stimuli. We therefore predicted lower success scores for emotional material for both groups in the inhibition condition. In relation to the particular emotional pattern observed in the DS population, we also expected that our DS group would err more than their matched controls in the “Happy–Sad” task, whereas we did not have specific assumptions for the “Sun–Moon” task. Regarding response latencies, we expected slower response times for both groups when processing emotional as opposed to neutral material, as reflected in the literature. We further assumed that the DS group would be slower than their controls when processing emotional material, because faces represent a highly captivating stimulus for them.

Materials and Methods

Participants

Forty-nine participants with DS took part in the study (31 men, 18 women), all with a moderate ID. All participants had a medical diagnosis of Trisomy 21 and were recruited from two sheltered workshops. Significant sensory, psychiatric, or physical disabilities, as well as clinical symptoms of dementia, constituted exclusion criteria for participation. The mean age of this group was 33.78 years ($SD = 9.00$). Adults were individually matched on gender and on the raw score of a receptive vocabulary task with a control group comprised of typically developing children attending an elementary public school (mean age $= 5.88$, $SD = 1.05$). The vocabulary task was the French adaptation of the Peabody Picture Vocabulary Test-Revised (Dunn, Thériault-Whalen, & Dunn, 1993). On this task, the DS group obtained a mean raw score of 67.28 ($SD = 25.13$) and the control group had a mean score of 68.24 ($SD = 24.96$). This difference was not statistically significant,

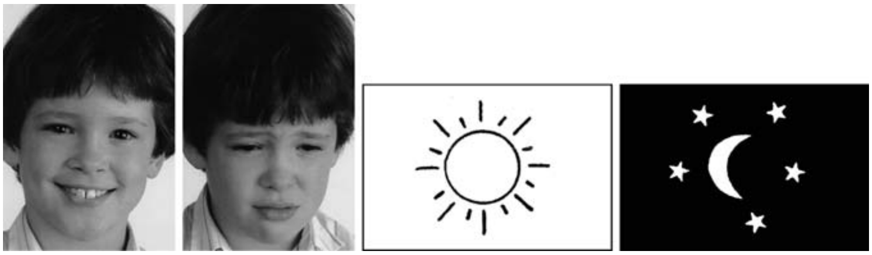

Fig. 1. Stimuli used in the "Happy–Sad" and "Sun–Moon" tasks.

$t(96) = -.19$, $p = .85$. These scores corresponded to a developmental verbal age of 6.27 years for the DS and of 6.34 years for the control group. In addition, productive vocabulary ability (frequent words) was assessed with a subtest taken from the French Isadyle Battery (Piérart, Comblain, Grégoire, & Mousty, 2007) in order to check for its potential influence on the experimental tasks. The DS group obtained a mean percentage score of 83.42 ($SD = 10.40$), and the control group had a mean score of 82.26 ($SD = 11.72$). These scores were not statistically different, $t(96) = .52$, $p = .605$.

Apparatus and Stimuli

The experiments were conducted on a laptop running E-Prime-1.0 (Schneider, Eschman, & Zuccolotto, 2002). Stimuli were randomly displayed one at a time and the software recorded the response latencies per stimulus. Participant responses were recorded directly by the experimenter using computer. Vocal responses registered by the computer had to be ruled out due to pronunciation and speech difficulties frequently encountered in the DS population. Similarly, in order to prevent disadvantage of the participants having motor difficulties, a key-press response time was not used. In addition, this type of responding adds the memory load of remembering which buttons to press, which might have interfered with the tasks. Once the response was triggered, the experimenter pressed one of the two mouse buttons to stop the time. The response was then coded as correct (left button) or incorrect (right button). The response items used in both tasks (*soleil, lune, content*, and *triste*) had a high mean lexical frequency ($M = 27.670$; range = 16.423–45.939; database intended for children of primary school, Lambert & Chesnet, 2001).

The stimuli were presented in black-and-white (see Fig. 1). For the "Sun–Moon" task, we used the original stimuli from the study by Gerstadt and colleagues (575 × 383 pixels). The stimuli of the "Happy–Sad" task (two faces; 400 × 575 pixels) were adapted from a set of facial pictures belonging to a children's game (*Jeux de visages*, Editions Nathan). This game contains photographs of a boy and a girl displaying various emotions. In order to select the experimental stimuli, the photographs displaying expressions of joy and sadness were first shown to five experts at the Facial Action Coding System (Ekman & Friesen, 1978) at Geneva University. They were asked, in an open-ended fashion, to name the emotion which they thought best described each photograph. Joy and sadness were recognized by all experts for the boy's pictures. For the girl's picture, joy was accurately recognized, but sadness was identified as sulk by four experts. The same pictures were then shown to 22 adults (11 women; mean age = 30.64, $SD = 6.17$) and 26 children (13 girls; mean age = 6.19, $SD = 0.8$) using the same procedure. The expression of joy was accurately identified by both groups from the two photographs. The expression of sadness for the boy's picture was recognized as such by 96% of the children and 87% of the adults. The girl's picture was recognized as sad by 65% of children and only 18% of adults. Given these results, we selected the boy's pictures. While it is generally recognized that pictures of men displaying an angry expression are perceived as more threatening than women's pictures (Mazurski et al., 1996), there is to our knowledge no corresponding assumption for the expression of sadness.

Procedure

All participants were tested individually by a trained clinical psychologist in a quiet room at their workplace or at school. The Stroop-like tasks were administered separately in two sessions approximately 2 weeks apart, and their order was counterbalanced. Each experimental task was composed of three events: (a) a black central fixation cross for 1,000 ms, (b) the stimulus displayed on a white background, and (c) a blank white screen (duration 1,000 ms). Each stimulus remained until the response was given. Participants were asked to respond as quickly as possible while avoiding mistakes. The assessment always began with the control condition, where participants were instructed to state what was being shown on the screen. This allowed us to monitor comprehension of the basic instructions and to measure basic processing speed. This condition

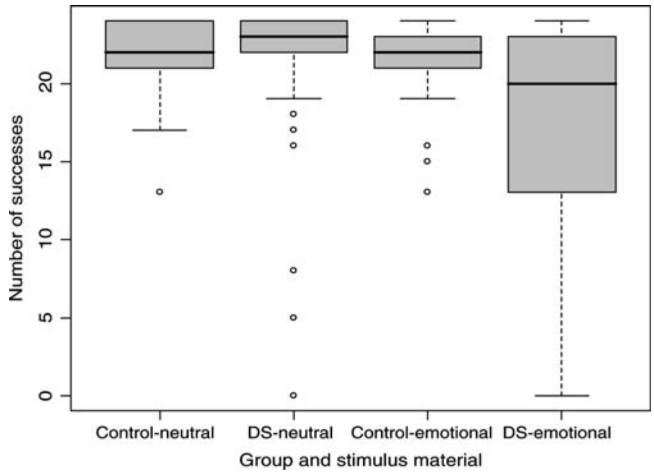

Fig. 2. Distribution of the number of successes by group and stimulus material.

was followed directly by the inhibition condition, in which participants were instructed to state the opposite of what was being shown on the screen. Each condition had 24 items equally distributed among the two stimuli. Two success rate scores and two reaction times scores were calculated for each task. Training trials with response-appropriate feedback were administered at the beginning of each condition to ensure its comprehension. Testing did not begin until these trials yielded accurate responses, and a limit of three attempts was set to avoid learning effects. In the "Happy–Sad" control condition, participants were instructed to respond with "happy" when shown the smiling child's picture, and to respond with "sad" to the sad child's picture. At the end of the presentation of the 24 items, a blank screen with the sentence "*change of task*" appeared, and the experimenter then explained the rules for the inhibition condition. Participants were instructed to respond "happy" to the picture of the sad child's picture, and "sad" to the smiling child's picture. The procedure for the "Sun–Moon" task was strictly equivalent.

Results

Analysis of the Number of Successes

In order to control comprehension of neutral and emotional material, the number of successes in the control condition was first considered. The success rates were equivalent in the DS and control groups for both tasks (percentage between 95.3 and 98.3 for both groups). The number of successes in the inhibition condition was then analyzed, resulting in a success rate that was contingent upon the group and the stimulus material. Consequently, our subsequent statistical analyses took into account this score for the inhibition condition only. A generalized linear mixed model (McCulloch & Searle, 2001), with group and presentation order as between subject factors and material (neutral versus emotional) as the repeated measures factor, was conducted on the number of correct responses. The use of a regular ANOVA with repeated measures was not possible due to the nature of the scores (a sum of successes following a binomial distribution), and also because the assumptions of the ANOVA were violated.

The analysis revealed that there was a significant main effect of material, $z = -8.79$, $p < .001$, indicating that the probability of success was lower for emotional when compared with neutral material. The presence of a significant interaction between material and group ($z = -6.70$, $p < .001$) was observed, showing that the DS group performed worse with the emotional material than the control group (Fig. 2). There was no significant main effect of presentation order, but there was a significant interaction between the presentation order and stimulus material, $z = 3.16$, $p < .01$. An improvement of all participants throughout the task was observed, but only when assessment began with the emotional material.

Finally, we examined the potential influence of the two emotional stimuli on the number of successes in the emotional task. We estimated a generalized linear mixed model using a binomial distribution, with group as the between-subjects factor and material (Sad vs. Happy) and condition as the repeated-measures factor (control vs. inhibition) on the number of successes. There was no effect of group or material, indicating that both groups processed the "sad" and "happy" items indiscriminately.

Response Time Analysis

Preliminary analyses showed that the distribution of latency scores did not vary by response accuracy for the two groups; thus, we carried out analyses by taking into account all response times. We first calculated the median of the 24 measures of response time for each participant. The median was chosen in order to minimize the effect of extreme values. A mixed ANOVA, with group and presentation order as between-subjects factors and material and condition as repeated-measures factors, was conducted on the logarithm of the median response times. The logarithm was chosen to normalize the response time distribution. The analyses revealed two significant main effects: material, $F(1,91) = 26.39$, $p < .001$; and condition, $F(1,91) = 306.09$, $p < .001$. There was also a significant interaction between material and condition, $F(1,91)=4.94$, $p < .05$. It took more time to process emotional than neutral material for both DS and control groups. Contrary to our expectations, there was no main effect or interaction of group. The DS participants did not take more time to respond than controls.

Second, we were interested in investigating whether a learning process might emerge throughout testing. To explore this possibility, we divided the 24 response time measures into three separate periods: the median times for the items 1–8, 9–16, and 17–24. An ANOVA, with group and presentation order as the between-subject factors and material, condition, and period ("item 1–8" vs. "item 9–16" vs. "item 17–24") as repeated-measures factors, was conducted on the logarithm of the median response times. As before, there was a main effect of material, $F(1,90) = 25.05$, $p < .001$, and a main effect of condition, $F(1,90) = 295.67$, $p < .001$. The interaction between material and condition was also significant, $F(1,90) = 8.94$, $p < .01$. Of interest was the presence of a significant interaction between time and group, $F(1,180) = 9.43$, $p < .001$. Whereas the control group response times were constant through the task, the DS group improved their median response times during the second period of assessment.

Finally, we tested the difference in response times between the "Sad" and the "Happy" stimuli. We conducted an ANOVA on the logarithm of the median response times for each of the 12 "Happy" and "Sad" stimuli, with group as the between-subjects factor and material (Sad vs. Happy) and condition (control versus inhibition) as the repeated-measures factors. We found only a significant main effect of condition, $F(1,91)=161.00$, $p < .001$, indicating that the mean response times for the inhibition condition were higher than the control condition.

Discussion

The first goal of the present study was to develop and test a new emotional Stroop-like task adapted to assess inhibition abilities in people presenting ID. Our second goal was to compare participant performance when inhibiting emotional versus neutral stimuli. To achieve this purpose, two identical tasks varying only on the nature of the stimuli were proposed: the "Happy–Sad" task (emotional material), and the "Sun–Moon" task (neutral material). These tasks were administered to an adult population with DS and a control group matched on receptive vocabulary level. One of the major findings of this study is that DS participants exhibited greater difficulty inhibiting a prepotent response to emotional stimuli. The specificity of this impairment may be supported on two grounds. First, the results obtained in the control conditions showed a good understanding of the two types of stimuli per se by all participants. Second, DS participants' results varied in the inhibition condition depending on the material presented. Whereas they performed with the neutral material as well as their controls, their performance was worse with the emotional material. This difficulty in inhibiting a prepotent response to stimuli with emotional content can be considered specific to the DS group, because the control group's performance did not depend on the nature of the material.

This impairment might be associated with the DS participants' difficulties to process emotions (Hippolyte et al., 2008; Kasari et al., 2001; Turk & Cornish, 1998). In addition, it has been shown that facial stimuli generally require more attentional resources to be processed (Verbruggen & De Houwer, 2007), and engage additional cognitive abilities (e.g., face recognition, emotion perception) when compared with stimuli with neutral content (Schulz et al., 2007). In our study, we did not observe these difficulties in the control group, but they were possibly masked by a ceiling effect of the task. Thus, the DS group's larger error rates in the "Happy–Sad" task might be related to the increased cognitive demand of its stimuli. Moreover, the literature pointed out that the DS adults judged facial emotions as being more positive than they were (Hippolyte et al., 2008). This positive bias presented by DS adults was negatively related to the Day–Night task, showing that participants who assessed emotions as being more positive also displayed lower performance in this task.

This finding suggests that the bias could be related to an impulsive behavior, such that participants might have been unable to repress an overly positive judgment of the stimuli. According to the particular emotional pattern found in the literature, we may assume that our DS participants would have more difficulty inhibiting the "happy" than the "sad" items in the emotional task. These results would be in accordance with Schulz and colleagues (2007), who showed that healthy adults committed more errors inhibiting happy facial expressions than sad ones in a go/no-go paradigm. However, our results showed no differences in the DS group's error rate according to item. These results might be related to the nature of the positive bias found by Hippolyte and colleagues (2008). In that study, the bias did not rely exclusively on an overstatement for the expression of joy, but was also associated to the expression of sadness, perceived as less intense. Down syndrome adults were thus biased in their judgment of both positive and negative emotions.

Relating to response times, main results showed that both groups were slower in processing emotional material. This finding is consistent with previous studies using emotional Stroop paradigms, as well as with the idea that facial stimuli require more time to be processed than non-emotional stimuli (Schulz et al., 2007). It seems that facial stimuli induce an interference effect which could be interpreted as an attentional bias (Williams, Mathews, & MacLeod, 1996). In our study, this attentional bias towards emotional stimuli was found in both control and inhibition conditions, suggesting a general attention-capturing effect of these stimuli. The particularity of the emotional material might also be confirmed through the learning effect we observed. The analysis of the presentation order of the material showed that both groups improved their performance during the second assessment session, but only when beginning with the "Happy–Sad" task. Our results suggest that starting with emotional material helps to better process neutral material, but not the contrary. A transfer of competences might not take place as quickly for the facial stimuli as for the neutral ones, a finding that could be linked to the more salient value of facial cues (LeDoux, 1998; Verbruggen & De Houwer, 2007).

Contrary to our expectations, DS participants' response times were not significantly longer than those of their controls across any condition or material. This finding was surprising, because the DS population usually shows slower basic processing speed in comparison with control groups (typically developing children or participants with ID matched on mental age; e.g., Nadel, 1999; Rowe, Lavender, & Turk, 2006). Our results might be explained by the fact that the experimenter registered participants' responses. Indeed, experimental procedures which require a motor response place individuals with DS at a disadvantage, as they frequently present difficulties with motor planning and praxis (Fidler, 2005; Mon-Williams et al., 2001). Nevertheless, they presented a dissimilar pattern throughout the task. Whereas the control group median response times remained constant, those for the DS group improved for both materials from the second period of assessment onwards. These findings suggest that DS individuals are able to display progress even when processing a difficult task, though these results must be qualified as they relate only to response times and not to score accuracies. However, this improvement indicates an interesting learning potential in this group. Of importance, the error terms were spread across the tasks, showing that DS participants reduced their response times without impact on score accuracy. The response time constancy observed in the control group might be explained by the fact that the task was easy for them and required relatively few cognitive resources. Therefore, children may have performed at best from the start, and maintained a stable performance throughout the task.

Finally, we were interested in investigating whether or not response times would differ between happy and sad stimuli in the inhibition condition. Previous studies have shown that happy faces are processed faster than sad ones (Grimshaw, Bulman-Fleming, & Ngo, 2004; Leppanen & Hietanen, 2004), a finding that was also observed in inhibition conditions in a go/no-go paradigm (Schulz et al., 2007). However, we did not find any significant differences for both groups in this study, which corresponded to the observations we made for the success rate scores.

Our results showed the utility of an emotional Stroop-like paradigm for studying population with ID. The tasks we proposed furnish an interesting tool for investigating inhibition capacities for emotional and neutral material, as well as emotion processing indirectly. The measures we obtained showed a good sensitivity to the task with the DS participants, but this paradigm would also have utility among pre-school children and other clinical populations with a particular socio-emotional profile, such as Williams syndrome, X-fragile, or individuals with Autism and ID. Nevertheless, some limitations of our study must be addressed. Our results showed that DS participants presented an atypical response pattern in comparison with typically developing children. However, this study does not allow for the assertion that this pattern is specific to DS in relation to other populations presenting a genetic disorder associated with ID. Comparative studies will be necessary to investigate this issue. Another limit concerns the restriction of the paradigm according to the population assessed. The task demand is simple and might quickly reach ceiling in populations with higher cognitive abilities. As our stimuli consist of only two pictures per task, their level of difficulty might be increased by augmenting the number of emotional targets proposed (happy and sad expressions represented by different faces). In order to further investigate the specific impairment observed with the facial emotional stimuli, it would also be important to introduce other expressions such as angry or neutral faces. These studies could help us better to understand the role of emotion in inhibition processing difficulties. In addition, the emotional facial stimuli used in this study refer to a particular aspect of emotion, related to social relations and behavior. It would also be interesting to propose new versions introducing others types of emotional stimuli, for example, stimuli related to self-control (e.g., food) to see whether inhibition difficulties will take place under these conditions.

Conflict of Interest

None declared.

References

Amir, N., Freshman, M., & Foa, E. (2002). Enhanced Stroop interference for threat in social phobia. *Anxiety Disorders*, *16*, 1–9.

Archibald, S. J., & Kerns, K. A. (1999). Identification and description of new tests of executive functioning in children. *Child Neuropsychology*, *5*, 115–129.

Atkinson, J., Braddick, O., Anker, S., Curran, W., Andrew, R., & Wattam-Bell, J.et al. (2003). Neurobiological models of visuospatial cognition in children with Williams syndrome: Measures of dorsal-stream and frontal function. *Developmental Neuropsychology*, *23*, 139–172.

Beveridge, M., Jarrold, C., & Pettit, E. (2002). An experimental approach to executive fingerprinting in young children. *Infant and Child Development*, *11*, 107–123.

Carlson, S. M., & Moses, L. J. (2001). Individual differences in inhibitory control and children's theory of mind. *Child Development*, *72*, 1032–1053.

Constantine, R., McNally, J. R., & Hornig, C. D. (2001). Snake fear and the pictorial emotional stroop paradigm. *Cognitive Therapy and Research*, *25*, 757–764.

Dunn, L., Thériault-Whalen, C. M., & Dunn, L. M. (1993). *Peabody picture vocabulary test—Revised*. Toronto, ON: Psycan.

Dykens, E., Hodapp, R. M., & Evans, D. W. (1994). Profiles and development of adaptative behavior in children with Down syndrome. *American Journal on Mental Retardation*, *98*, 580–587.

Ekman, P., & Friesen, W. V. (1978). *The Facial Action Coding System: A technique for the measurement of facial movement*. Palo Alto: Consulting Psychologist Press.

Fidler, D. J. (2005). The emerging Down syndrome behavioral phenotype in early childhood. Implications for practice. *Infants & Young Children*, *18*, 86–103.

Gagliardi, C., Frigerio, E., Burt, D. M., Cazzaniga, I., Perrett, D. I., & Borgatti, R. (2003). Facial expression recognition in Williams syndrome. *Neuropsychologia*, *41*, 733–738.

Gerstadt, C. L., Hong, Y. J., & Diamond, A. (1994). The relationship between cognition and action: Performance of children 3 1/2–7 years old on a Stroop-like day-night test. *Cognition*, *53*, 129–153.

Grimshaw, G. M., Bulman-Fleming, M. B., & Ngo, C. (2004). A signal-detection analysis of sex differences in the perception of emotional faces. *Brain and Cognition*, *54*, 248–250.

Hippolyte, L., Barisnikov, K., & Van der Linden, M. (2008). Face processing and facial emotion recognition in adults with Down syndrome. *American Journal on Mental Retardation*, *11*, 292–306.

Kasari, C., Freeman, S. F. N., & Hughes, M. A. (2001). Emotion recognition by children with Down syndrome. *American Journal on Mental Retardation*, *106*, 59–72.

Kindt, M., & Brosschot, J. F. (1997). Phobia-related cognitive bias for pictorial and linguistic stimuli. *Journal of Abnormal Psychology*, *106*, 644–648.

Lambert, E., & Chesnet, D. (2001). Novlex: une base de données lexicales pour les élèves de primaire. *L'Année Psychologique*, *101*, 277–288.

LeDoux, J. E. (1998). *The emotional brain*. London: Weidenfeld & Nicolson.

Leppanen, J. M., & Hietanen, J. K. (2004). Positive facial expressions are recognized faster than negative facial expressions, but why? *Psychological Research*, *69*, 22–29.

Mazurski, E. J., Bond, N. W., Siddle, D. A., & Lovibond, P. F. (1996). Conditioning with facial expressions of emotion: effects of CS sex and age. *Psychophysiology*, *33*, 416–425.

McCulloch, C. E., & Searle, S. R. (2001). *Generalized, linear, and mixed models*. New York: John Wiley & Sons.

Mon-Williams, M., Tresilian, J. R., Bell, V. E., Coppard, V. L., Jobling, A., & Carson, R. G. (2001). The preparation of reach to grasp movements in adults with Down syndrome. *Human Movement Science*, *20*, 587–602.

Nadel, L. (1999). Down syndrome in cognitive neuroscience perspective. In H. Tager-Flusberg (Ed.), *Neurodevelopmental disorders*. (pp. 197–221). Massachussets: Institute of Technology.

Perez-Edgar, K., & Fox, N. A. (2003). Individual differences in children's performance during an emotional Stroop task: A behavioral and electrophysiological study. *Brain and Cognition*, *52*, 33–51.

Piérart, B., Comblain, A., Grégoire, J., & Mousty, P. (2007). Isadyle: Instruments pour le screening et l'approfondissement de l'examen des dysfonctionnements du langage de l'enfant. Marseille: Solal.

Roebers, C. M., & Schneider, W. (2005). Individual differences in young children's suggestibility: Relations to event memory, language abilities, working memory, and executive functioning. *Cognitive Development*, *20*, 427–447.

Rowe, J., Lavender, A., & Turk, V. (2006). Cognitive executive function in Down's syndrome. *British Journal of Clinical Psychology*, *45*, 5–17.

Schneider, W., Eschman, A., & Zuccolotto, A. (2002). *E-Prime user's guide*. Pittsburgh, PA: Psychology Software Tools.

Schulz, K. P., Fan, J., Magidina, O., Marks, D. J., Hahn, B., & Halperin, J. M. (2007). Does the emotional go/no-go task really measure behavioral inhibition? Convergence with measures on a non-emotional analog. *Archives of Clinical Neuropsychology*, *22*, 151–160.

Simpson, A., & Riggs, K. J. (2005). Factors responsible for performance on the day-night task: response set or semantics? *Developmental science*, *8*, 360–371.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology*, *18*, 643–662.

Tager-Flusberg, H., Sullivan, K., & Boshart, J. (1997). Executive functions and performance on false belief tasks. *Developmental Neuropsychology*, *13*, 487–493.

Turk, J., & Cornish, K. (1998). Face recognition and emotion perception in boys with fragile-X syndrome. *Journal of Intellectual Disability Research*, *42*, 490–499.

Verbruggen, F., & De Houwer, J. (2007). Do emotional stimuli interfere with response inhibition? Evidence from the stop signal paradigm. *Cognition and emotion*, *21*, 391–403.

Walley, R. M., & Donaldson, M. D. C. (2005). An investigation of executive function abilities in adults with Prader–Willi syndrome. *Journal of Intellectual Disability Research*, *49*, 613–625.

Watts, F. N., McKenna, F. P., Sharrock, R., & Trezise, L. (1986). Colour naming of phobia-related words. *British Journal of Clinical Psychology*, *77*, 97–108.

Williams, J., Mark, G., Watts, F. N., MacLeod, C., & Mathews, A. (1997). *Cognitive psychology and emotional disorders*. Chichester: Wiley.

Williams, J., Mathews, A., & MacLeod, C. (1996). The emotional Stroop task and psychopathology. *Psychological Bulletin*, *120*, 3–24.

Williams, K. R., Wishart, J. G., Pitcairn, T. K., & Willis, D. S. (2005). Emotion recognition by children with Down syndrome: Investigation of specific impairments and error patterns. *American Journal on Mental Retardation*, *110*, 378–392.

Wolfe, C. D., & Bell, M. A. (2007). Sources of variability in working memory in early childhood: A consideration of age, temperament, language, and brain electrical activity. *Cognitive Development*, *22*, 431–455.

Wright, I., Waterman, M., Prescott, H., & Murdoch-Eaton, D. (2003). A new Stroop-like measure of inhibitory function development: typical developmental trends. *Journal of Child Psychology and Psychiatry*, *44*, 561–575.